PROCEEDINGS OF THE FIRST INTERNATIONAL CONFERENCE ON RAMMED EARTH CONSERVATION, RESTAPIA 2012, VALENCIA, SPAIN, 21–23 JUNE 2012

Rammed Earth Conservation

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CRC Press
Taylor & Francis Group
Boca Raton London New York Leiden

CRC Press is an imprint of the
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A BALKEMA BOOK

Cover photo: Rammed earth in the Bofilla Tower in Bétera (Valencia). Photo by Vegas & Mileto.

CRC Press/Balkema is an imprint of the Taylor & Francis Group, an informa business

Typeset by V Publishing Solutions Pvt Ltd., Chennai, India
Printed and bound in in Great Britain by CPI Group (UK) Ltd, Croydon, CR0 4YY

Published by: CRC Press/Balkema
P.O. Box 447, 2300 AK Leiden, The Netherlands
e-mail: Pub.NL@taylorandfrancis.com
www.crcpress.com – www.taylorandfrancis.com

ISBN: 978-0-415-62125-0 (Hbk + CD-ROM)
ISBN: 978-0-203-08565-3 (eBook)

Rammed Earth Conservation - Mileto, Vegas & Cristini (eds)
© 2012 Taylor & Francis Group, London, ISBN 978-0-415-62125-0

Restoration of the Andalusí wall of the Alcazaba Antigua (Ancient Citadel) of Granada (Cuesta de Alhacaba area)

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ABSTRACT: The primitive Andalusí wall of the Alcazaba Antigua of Granada was strengthened on the northern side by means of the construction of further outer wall, parallel to the existing one, in the area just next to the Cuesta de Alhacaba. This new wall, of a larger size than the inner one, was 350 m long, stretching between Puerta del Ensanche (*Bab al-Ziyada*) and Puerta Monaita (*Bab al-Unaydar*), with fourteen intermediate towers. It was built by means of *tapia calicostrada* (lime-crusted rammed earth) walls. In some towers and panels the original parapets and crenellations have been maintained. This part of the wall was subjected to consolidation and restoration in the period 2002-2006. The purpose of this work was to recover the structural safety and to facilitate observation of the original elements that have been preserved, and of contributions of previous interventions, while undergoing minimum changes in the visual image of the walls.

1 BACKGROUND

1.1 *Historical introduction*

The hill situated on the right-hand bank of the River Darro was a settlement of the Iberian-Roman *Iliberri*. The limits must have coincided with those of the first *Madina Garnata* Andalusí on the northern and western sides, where there are steep escarpments. The fact that the capital of the new Taifa kingdom of the Ziri dynasty was established in Granada at the beginning of the 11th century led to the strengthening of the old walls. A few decades afterwards the city expanded towards the plain and the walled precincts were considerably enlarged; the first precincts became the centre of power under the name of *Alcazaba Antigua* (Ancient Citadel). At a later date the fortification on the northern side was reinforced, in the area just close to the Cuesta de Alhacaba, with the construction of another exterior wall parallel to the existing one, with gates at both ends (Fig. 1). This must have been built in the period of the Almoravids (1090-1157) (Torres 1952, Marcos 2010), or maybe in the Almohad period (1157-1232) according to other authors (Márquez & Gurriarán 2008). The fact that Granada was chosen as capital of the Nasrid dynasty in 1237 led to the construction of a new palatine city on the Alhambra hill, and therefore the Ancient Citadel lost both political and military interest. Half way through the 14th century this area was left intramural, as the northern suburb of the city, called the Albaicín, was surrounded by the outer city walls (Orihuela 2001).

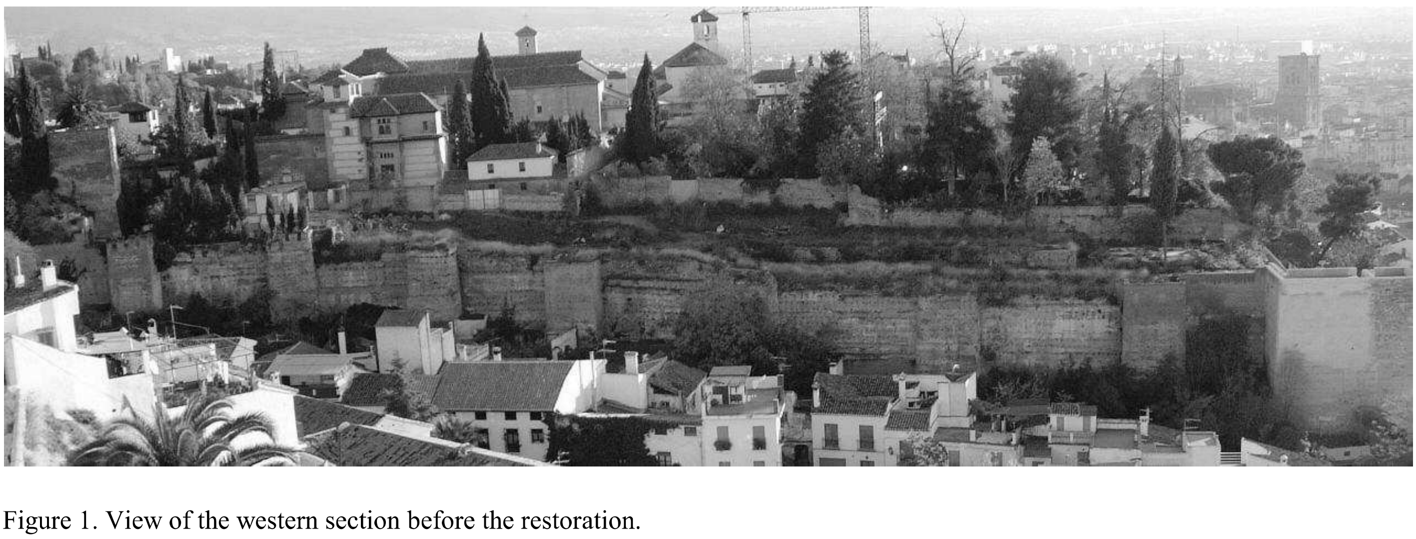

Figure 1. View of the western section before the restoration.

1.2 *Restorations*

In this sector there is evidence recorded of seven interventions of consolidation and restoration. With the exception of the last one, they were all directed by Francisco Prieto-Moreno Pardo, who was the conservation architect of the 7th area. The three projects of the 1950s were based on urgent tasks of underpinning of foundations and consolidation of wall faces, by means of concreted rubblework and ordinary rubblework respectively. In 1962 there was an additional repair job of the wall faces with a minor loss of mass, by means of solid masonry brickwork rough rendered with lime mortar and clayey earth, and an effort to find a similar tone to that of the well-preserved rammed earth wall or *tapias*. However, in 1963 the decision was taken to leave the repairs with solid masonry brickwork exposed, although in areas with superficial crust decomposition they continued to apply the same aforementioned rendering. This new criterion, justified by the convenience of distinguishing the new (brickwork) from the original (*tapias*) continued to be applied in the 1968 project. There may also have been influence in the change of criterion, although this is not indicated in the written records, due to the poor adherence of the lime mortar used on the masonry brickwork grouted with mortar from Portland cement.

Following the 1982 project, the architect Ana Iglesias took action on the intramural wall face between the *Bab al-Ziyada* and tower 5. She changed the criteria and the previous constructive techniques, because she was intending to achieve mimesis with *the existing tapias by means of shuttered pseudo-tapias*. White cement was used as agglomerate, but on applying it laterally and not from above, it lacked the necessary rammed action. The inner strengthening with bars of corrugated steel and electro-soldered mesh has contributed to the considerable deterioration of this intervention, even after a period of less than thirty years.

2 DESCRIPTION OF THE WALL

The stretch of wall subject to intervention is 350 m long, between Puerta del Ensanche or de las Pesas (*Bab al-Ziyada*) and Puerta Monaita (*Bab al-Unaydar*), with fourteen intermediate towers, and it can be divided into two areas (Fig. 2). In the centre of the eastern one, beginning in the first aforementioned door, there are three semi-cylindrical towers and another prismatic one, all of a large size and considerably separated. When we reach tower 7, which was initially built as an *albarrana* (a flanking tower linked to the wall by a brick vault), there is a turn in direction and a break in the parapet walk, and the 150 m of the western area runs on to a plateau at a lower level than the previous one. The seven towers of this sector have a rectangular layout, are fairly near each other and stand out only a little from the wall. Towers 8 and 9 and the panel between them have maintained the parapet and the crenellation, with two loopholes carved in the parapet. The average height of these stretches is about 10 m, and reaches a height of 15 m in some towers; the width varies between 2.70 – 3.60 m. The towers stand out

Figure 2. Plan and elevations before and after the restoration.

two courses of *tapias* above the panels and they can be reached from the parapet walk by very high steps, shuttered in the *tapias* of the towers. They were built by means of greyish *tapias calicostradas* (rammed earth with a hard lime crusted surface) with courses of 71-84 cm in height. They had *agujas* (pieces of wood for sustaining the shuttering) of boards of 8 x 2.5 cm that were set inside, except in the parapets, where they could be retrieved. In almost all the towers and panels we can see various impressions left by the esparto grass rope on the surface of the wall, and situated horizontally at the height of the *agujas*. Possibly these ropes were used to control the horizontal level of the construction, as they utilized several plank moulds at the same time (Fig. 8).

This sector of the wall was submitted to consolidation and restoration work during the period of 2002-2006, under the direction of one of the authors of this paper (J.M.C.), with separate advice from the other author (A.O.). One of the two towers preserved above ground level of the inner wall was also restored, and this we have referred to as 7I. Both this tower and the stretch 5-6, and particularly tower 7 of the outer wall, retain on their outer face decorative traces of white band 4.5 cm wide, to accentuate the courses there (Fig. 3). This type of adornment has been considered in other Andalusí fortifications as specific of the Almohad dynasty (Azuar 1996).

3 PATHOLOGIES DETECTED IN THE WALL

3.1 *Natural pathologies*

Problems of stability of banks of the natural conglomerate of the hill where the Ancient Citadel is situated in the proximity of towers 2, 3, 5 and 6, as well as in the panel between towers 2-3; deterioration due to atmospheric conditions, particularly winter frosts; the presence of parasite vegetation rooted into the wall and its immediate surroundings, as well as lichen and dirt on the wall faces; the existence of nests of insects, birds and rodents, which had made their breeding and resting place here in these *agujas* holes.

3.2 *Anthropic pathologies*

The presence of insignificant attached buildings of no interest, brackets of television aerials and electric cables; cavities made in the wall faces by people who used them as store rooms, wood sheds, etc; the excavation of caves under the foundations of some panels of the outer wall; elevation of the original height of the wall, filling up on top of towers and panels, to achieve horizontal surfaces in the gardens of properties that were previously intramural.

4 RESTORATION CRITERIA

After consolidating everything that was deemed necessary for restoration, the main objective is that it should be unnoticeable from a distance, but that it can be observed by those who wish to investigate and appreciate the remains under conservation. Our aim has been to respect as far as possible the previous actions of restoration without detriment to the security and protection of the restoration and the original materials.

All the accessible wall faces of towers and panels were restored as well as their upper parts so the conditions for draining away rainwater were improved. No work was done on the intramural wall face situated between the Puerta de las Pesas and tower 5, which had undergone intense restoration in the 1980s.

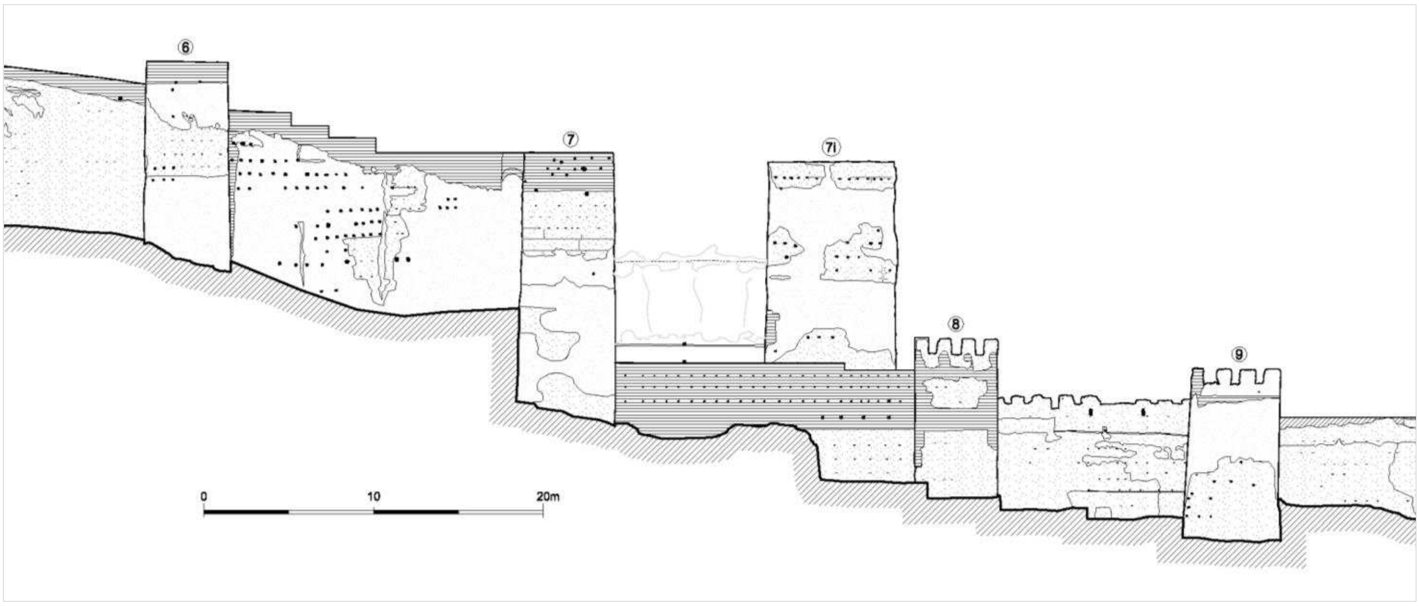

Figure 3. Elevation of the central section after the restoration.

The small *agujas* holes that had grown larger due to the action of groups of animals, as mentioned previously, were filled up sufficiently to hinder them nesting, but not completely, to avoid any radical change in the previous image of the wall. Nevertheless, the large anthropic cavities in the wall faces were totally blocked up. The caves excavated under some panels were also filled in using heavy stone lime concrete (Figs. 4-6).

5 RESTORATION TECHNIQUES

Stabilization of banks and underpinning of foundations was carried out using masonry walls.

5.1 *Selection of the type of mortar for reintegration*

The type of mortar used for reintegration of vertical and superior wall faces was established after analyzing the Study of Characterization of Materials and a series of trials carried out in situ, with monitoring during a winter period. Three different compositions of the agglomerate were experimented with: aerial lime only, a mixture of aerial lime and hydraulic lime, or a mixture of both types of lime and white cement with the same proportion of the three products. The best results were obtained with the latter formula and a proportion of aggregate/sand of 1:2. It cannot be forgotten that the implementation work is itself a coating applied laterally to a wall and not the traditional one of rammed earth from above. The climatology of Granada also influences the result of the initial mixtures, as the enormous variations in temperature and winter frosts cause rapid deterioration of the upper layers, since they are exposed to the water and inevitably this is manifest in the freezability of the material. It has been proved that this effect is lesser with the chosen composition, although precaution must be taken not to damp proof until the water of the mixture has completely evaporated.

Filling the fissures and cracks was carried out with the system of putting in plugs from the bottom upwards, therefore guaranteeing the greatest possible filling of the cracks with mortar or lime slurry. To do this the crack was sealed in stretches of 50 cm and the mortar was poured in until it flowed out of the top, in order to avoid pockets or empty areas.

5.2 *Cleaning of the wall faces with preserved tapia crust*

Cleaning of the wall faces was done using a jet of high pressure water, whether the coating was in good condition or deteriorated or almost inexistent. Further to this a consolidation treatment was given, with lime water in the case of partially eroded courses, and finally a damp-proof product (Tegosivín). These joint actions have given the best result in the curves of absorption-desorption, as it reduced the speed of absorption of water and its capacity of retention, and at the same time it doesn't produce any significant alteration in the degree of drying out. There were positive effects of cleaning the surface on the degree

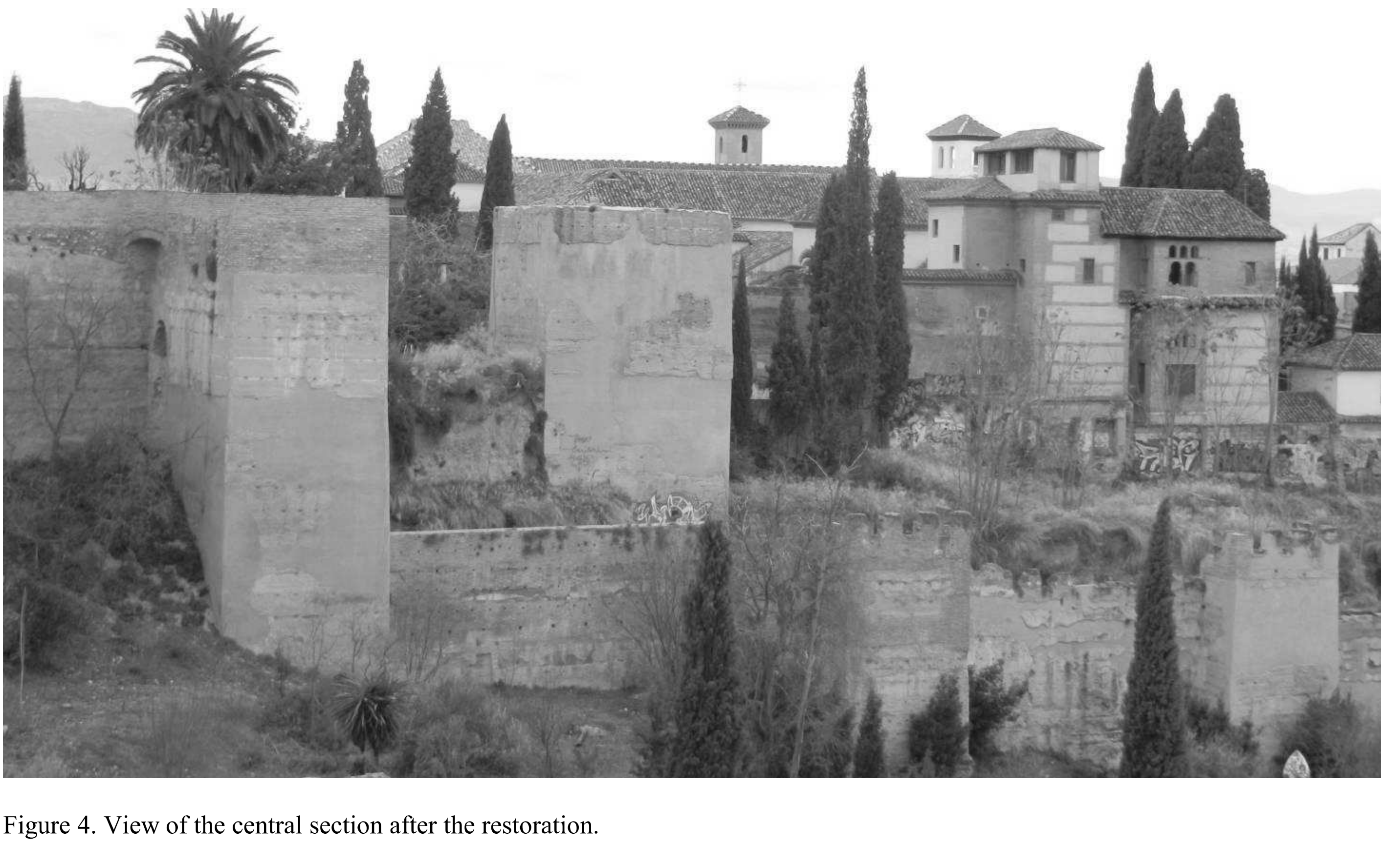

Figure 4. View of the central section after the restoration.

of hardness; with this treatment the superficial area that was most modified was eliminated, therefore improving the properties of the material. The aesthetic result is correct, since this treatment cleans the wall faces without changing the colour or its texture. The permeability to the water vapour was also tested.

5.3 *Areas with eroded tapia crust*

In the areas where the *tapia* crust was eroded to a depth of about 4 cm from the original surface, a mechanical cleaning was carried out to eliminate loose or degraded elements, until it became a good base on which to place the later treatment. Further to this, an impregnation was applied with 20 coats of lime water, in order to achieve a correct consolidation of the material. The process was completed by damp-proofing the surface. Also in this section we include the inner consolidation of cavities of crumbled fragments that should be maintained, and therefore consolidated, which was done by means of cleaning with high pressure water, followed by consolidation with lime water then sealed with hydraulic lime mortar.

Figure 5. View from tower 8 to tower 14 before the restoration.

5.4 *Areas with loss of mass*

In this project three levels of loss of mass in the wall surfaces were considered: a superficial one, loss of medium depth and large cavities. The reason for this distinction was that of applying in the reintegration of each level slightly different material, which could facilitate and accelerate the implementation of the work.

The first level included deterioration between the crust and about 8 cm of depth. The material applied was the mortar described in section 5.1, with semi-coarse aggregate, i.e. aggregate up to nº 6 in the whole mass.

The second level included deterioration with loss of mass between the crust and about 20 cm. In this case the same mortar was used in the superficial levels, but in the deeper ones mortar with coarse aggregate. In the third level, foreseen only in the existing cavities, an aerial lime concrete with stone aggregate was used in depths greater than 20 cm, changing to the previous material on reaching the corresponding levels.

The aggregate of the restitution material used on the most superficial layer, which should remain uncovered, was selected with adequate soil texture and aggregates of different origin were mixed to achieve heterogeneity similar to material of the existing mass.

The exposed surface was left at a level -3 cm from the original finished surface, and a combed treatment was applied, consisting of combing to achieve a rough surface on which the aggregate could be observed. Afterwards, a series of horizontal lines of small depth were drawn, imitating the indication of the internal beds or strata of *tapias* with the purpose of avoiding a superficial homogeneity which was not desired. Using rather thicker lines, and equally superficial as the previous ones, the impression was made of the different courses of the *tapia*.

It was important that the thickness of the coats of reintegration mortar was not more than 1 cm, since due to the characteristics of this material a greater thickness would mean its cracking and becoming detached because of lacking sufficient air for carbonization. These coats were laid by throwing them gate would stick on to it. The edge of each of the coats

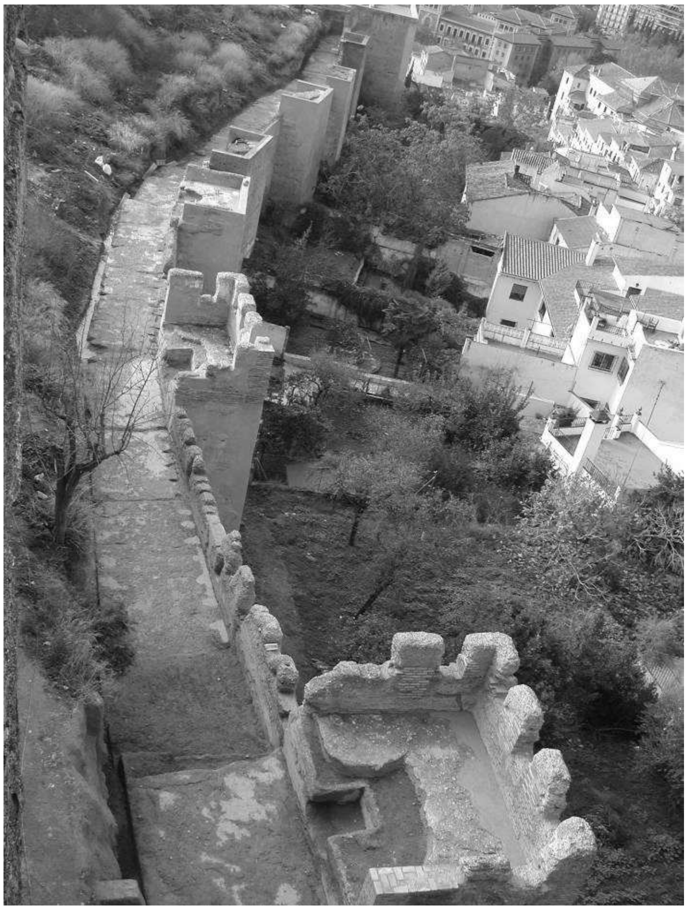

Figure 6. View from tower 8 to tower 14 after the restoration.

was gate would stick on to it. The edge of each of the coats was well closed on top of the previous one and on the base of the material (Fig. 7).

5.5 *Treatment of cracks*

The cracks were joined up using stainless steel staples after cleaning up the area and discovering the strong material in which to place the staple legs with resin. This resin was never less than 50 cm from the ultimate surface, to avoid producing any change in it. After this joining up operation, the important cracks and cavities existing in the walls were cleaned and filled up with mortar of the same characteristics as the aforementioned ones.

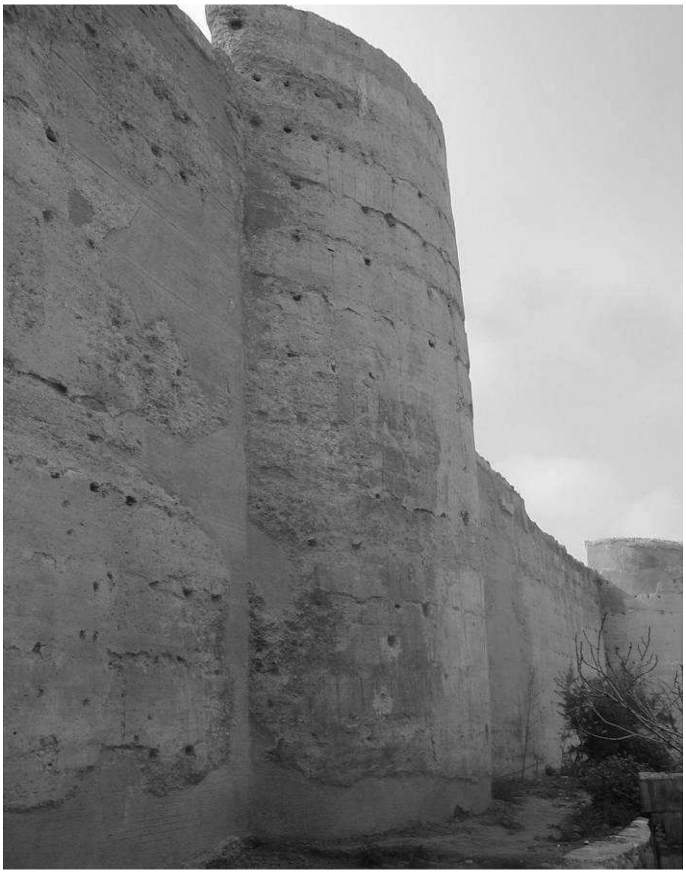

Figure 7. View of towers 2 and 3 after the restoration.

5.6 *Treatment of "agujas" and their holes*

It is well-known that the holes we refer to as *mechinales* are not associated with the original image of a wall like this one, built with set in *agujas* of wooden boards. They become manifest with the first deterioration and are the origin of a lot more. However, we consider that the presence of these holes has created a characteristic image of the ancient *tapia* walls, and that it should not be modified. Any steps regarding them were therefore taken according to the area where they were placed. Those situated in areas of crust in good condition or deteriorated were left as they were, cleaning them up and damp-proofing them. In the cases where their dimensions were disproportionate, their inner mixture was remade with mortar of a slightly darker tone, to simulate greater depth, and giving a slightly concave finish to the surface. The new depth of the hole was not more than 7 cm with regard to the surrounding surface. In the areas where wall mass was remade, no *mechinales* were presented on the surface. In those where the wooden *agujas* existed, the disintegrated material was cleaned and fumigated by injecting insecticide-fungicide (Xylazel). In the case of much deteriorated ones the latter was substituted by a consolidating material (Paraloid).

Figure 8. Detail of *aguja* and esparto grass trace on the *tapia*.

6 CONCLUSIONS

Consolidation and restoration have been carried out with due respect to part of the previous interventions and there have been minimum chromatic and volumetric changes in the existing Andalusí city walls. Almost a decade after commencing the work, the state of conservation is satisfactory.

NOTE

This paper has been part of the Investigation Project "Nasrid cities: urban structure, system of defense and water supply" (HAR2011-30293) of the National Plan I+D+i 2008-11.

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